

REMARKS

Claims 1-5, 9, 10 and 15-21, all the claims pending in the application, are rejected. In addition, claims 1-5, 9, 10 and 15-21 are objectionable. Claims 1, 2, 4, 19 and 20 are amended. Claim 3 is cancelled.

The -amendment to the claims is clearly supported by the description of page 2, line 25 to page 4, line 2 in the present specification. Furthermore, the feature recited in the original claim 3 is incorporated into independent claims 1, 2, 3, 4, 19, and 20, respectively.

Claim Objections

The Examiner objects to the language in each of claims 1, 2, 4, 19 and 20 because the word “an” is missing. Applicants appreciate the Examiner’s suggestion. Correction has been made in accordance with that suggestion.

Claim Rejections - 35 U.S.C. § 103

Claims 1-2, 3/(1-2), 9-10 (1-2), and 17 (1-2) are rejected under 35 U.S.C. § 103(a) as being unpatentable over Berkey et al. (U.S. Patent No. 6,265,115) in view of either Okamoto et al. (U.S. Patent No. 6,020,109) or Shoki et al. (U.S. Pub. No. 2002/0110743), and further in view of Jacquinet et al (U.S. Patent No. 6,126,518) and Miura (U.S. Patent No. 6,027,669) as evidenced by Grant et al (Grant & Hackh’s Chemical Dictionary, Fifth Ed., 1987). This rejection is traversed for at least the following reasons.

The Claimed Invention

The present invention relates to a glass substrate for a phase shift mask blank to be exposed by an ArF excimer laser, a glass substrate for a phase shift mask blank to be exposed by an F₂ excimer laser, or a glass substrate for a EUV reflective mask blank, in which a phase defect occurs when fine protrusions are present on a principal surface of a glass substrate.

In the glass substrate for the phase shift mask blank in which the above-mentioned exposure wavelength of the exposure light is used, the problem of a change in phase angle becomes significant, due to presence of the fine protrusions, and result in an undesirable phase defect. In order to avoid such defects, it is required that a polishing method be applied so that a

rate of occurrence of the fine convex defects formed on the surface of the substrate is zero or very low.

As described at page 3, lines 1-15 in the present specification, as the exposure wavelength becomes shorter, the influence of the convex protrusions becomes greater. Indeed, the problem of the phase defects is of critical proportions in next-generation of lithography, which uses an ArF excimer laser, an F₂ excimer laser, or an EUV (Extreme Ultra Violet) light source as an exposure light source.

For example, assume that the convex protrusions have a height of 5 nm. If the exposure light is ArF having the wavelength of 193 nm, the change in phase angle is 4.6 degrees. If the exposure light is F₂ having the wavelength of 157 nm, the change in phase angle is 5.7 degrees. Next, consider the case where an EUV reflective mask blank or an EUV reflective mask is produced by the use of the glass substrate with the convex protrusions having a height on the order of several nanometers. If the convex protrusions have a height of 5 nm, the change in phase angle exceeds 20 degrees when the exposure wavelength is 13.5 nm. The change in phase angle results in degradation of CD (Critical Dimension) error characteristics, which is an significant problem.

Under this circumstance, according to the present invention, the surface of the glass substrate is polished by the use of the polishing liquid containing the colloidal silica abrasive grains produced by the specific manufacturing method, i.e., "hydrolysis of an organosilicon compound". Consequently, it is possible to suppress occurrence of the protrusions which cause the phase defect.

Further, if the colloidal silica abrasive grains are produced by the above-mentioned specific manufacturing method, high-purity colloidal silica abrasive grains are obtained. The high-purity colloidal silica abrasive grains produced in the above-mentioned manner have a purity as extremely high as 99.99999% and contain very little impurities including alkali metal, such as Na and K, and heavy metal, such as Fe, Al, Mg, and Ti. Therefore, it is possible to suppress occurrence of fine convex surface defects formed on the glass substrate when a gel-like substance by alkali metal or heavy metal impurities are adhered to the glass substrate and serve

as a mask to cause a difference in polishing rate or etching, as described at page 7, lines 18-28 in the present specification.

The Prior Art

With regard to differences between the present invention and the cited references (Jacquinot, Miura, Grant, Okamoto, Shoki, Maekawa, Yoshikawa), Applicants respectfully point to the following differences:

Berkey discloses use of the colloidal silica and use of the short wavelength such as ArF as the exposure light source. However, the colloidal silica of Berkey is not produced by hydrolysis of an organosilicon compound. Further, the colloidal silica is not a neutral polishing liquid. If the Berkey colloidal silica is used in the polishing process, fine protrusions would be generated so as to cause the phase defect.

By contrast, according to the present invention recited in the amended claim 1, the surface of the glass substrate is polished by the use of a polishing liquid containing the colloidal silica abrasive grains produced by hydrolysis of an organosilicon compound, a content of alkali metal in the colloidal silica abrasive grains being 0.1 ppm or less. Further, the polishing liquid has the neutral region (a pH value between 7.0 and 7.6). As a consequence, it is possible to suppress occurrence of the fine protrusions, which cause the phase defect.

Miura discloses a wide variety of techniques for manufacturing colloidal silica for the purpose of preventing reduction in the polishing rate by adopting the specific electric conductivity upon recycling. One example of the manufacturing methods for producing colloidal silica for this limited purpose is “hydrolysis of an organosilicon compound”.

In Miura, as among all of the manufacturing methods used to produce colloidal silica, none but the method of “hydrolysis of an organosilicon compound” can produce high-purity colloidal silica abrasive grains containing very little impurities including alkali metal or heavy metal. In other word, there is no focus in Miura of suppressing occurrence of the protrusions which cause the phase defect. As to the use of “hydrolysis of an organosilicon compound” to produce colloidal silica, there is no recognition that such colloidal silica will suppress the occurrence of protrusions.

Thus, Miura fails to teach that only the colloidal silica produced by “hydrolysis of an organosilicon compound” is effective so as to suppress occurrence of the protrusions which cause the phase defect.

Accordingly, one of ordinary skill in the art would not know to apply the colloidal silica produced by “hydrolysis of an organosilicon compound” of Miura in order to achieve the goals of the present invention. Specifically, Miura fails to teach selecting “hydrolysis of an organosilicon compound” among the various manufacturing methods in order to suppress occurrence of the protrusions which cause the phase defect. Thus, the present invention is not obvious to one of ordinary skill in the art.

Jacquinet discloses a semiconductor substrate as a focus of the application of colloidal silica. By contrast, according to the present invention, use is made of the glass substrate for the phase shift mask blank to be exposed by the ArF excimer laser, the glass substrate for the phase shift mask blank to be exposed by the F₂ excimer laser, and the glass substrate for the EUV reflective mask blank. Jacquinet is not concerned with phase defects of the type of concern to the present invention and Jacquinet fails to disclose the specific application used in the specific wavelength according to the present invention. Thus, the present invention is different from Jacquinet in that it is applied to a substrate for a mask blank and there is no teaching or suggestion for application of the techniques in Jacquinet to a substrate for a mask blank.

Further, there is no teaching or suggestion, and indeed it would be technically difficult, to apply the teachings for a semiconductor substrate of Jacquinet to the above-mentioned specific application in view of the goal in the present application for achieving a high degree of flatness.

Okamoto merely discloses the phase shift mask. Okamoto fails to teach the problem with respect to the phase defects due to the fine convex surface defects on the surface of the glass substrate.

Further, Okamoto discloses only the step of polishing and cleaning before the Cr-sputtering step with respect to the polishing method of the glass substrate. Thus, Okamoto fails to disclose the polishing method of the present invention.

Shoki discloses only the EUV mask blank, the glass substrate and the surface roughness thereof. Further, Shoki discloses only the mechanical polishing as a specific polishing method. Thus, Shoki fails to disclose the polishing method of the present invention.

Claims 4-5, 9-10(4), 15-16, 17(4) and 21 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Yoshikawa et al. (U.S. Pub. No. 2003/0228461) in view of Watanabe et al. (U.S. Patent No. 6,277,465), and Maekawa et al. (U.S. Patent No. 5,868,953), and further in view of Berkey et al. (U.S. Patent No. 6,265,115) and either Okamoto et al. (U.S. Patent No. 6,020,109) or Shoki et al. (U.S. Pub. No. 2002/0110743). This rejection is traversed for at least the following reasons.

The Claimed Invention

Independent claim 4 is directed to the production of a glass substrate for a glass blank, which necessarily focuses the invention on specific quality requirements, as already discussed. The claim has been amended to specify the presence of protrusions that cause phase defects and the use of an alkali metal content in colloidal silica abrasive grains at a level of 0.1 ppm or less. This permits the achievement of the desired phase performance.

The Prior Art

Yoshikawa discloses polishing the glass substrate for an information recording medium as application.

By contrast, according to the present invention, as application, use is made of the glass substrate for the phase shift mask blank to be exposed by the ArF excimer laser, the glass substrate for the phase shift mask blank to be exposed by the F₂ excimer laser, and the glass substrate for the EUV reflective mask blank. Yoshikawa fails to disclose the specific application used in the specific wavelength according to the present invention. Thus, the present invention is different from Yoshikawa in application of the substrate.

Further, it is difficult to apply the glass substrate for the information recording medium of Yoshikawa to the above-mentioned specific application in view of increasing productivity and flatness.

Maekawa and Watanabe disclose the glass substrate for magnetic disk as an application. By contrast, the present invention is applied to the production of a glass substrate for a phase shift mask blank to be exposed by the ArF excimer laser, a glass substrate for the phase shift mask blank to be exposed by the F₂ excimer laser, and a glass substrate for the EUV reflective mask blank. Both Maekawa and Watanabe fail to disclose the specific application used in the specific wavelength according to the present invention. Thus, the present invention is different from Maekawa and Watanabe in application of the substrate.

Further, the present invention is characterized in the surface roughness control step using the polishing liquid comprising colloidal silica abrasive grains in the polishing process and the protrusion suppressing step of using the polishing liquid comprising colloidal silica abrasive grains, controlling to a pressure lower than the predetermined pressure and suppressing occurrence of a fine convex protrusion. By contrast, Maekawa and Watanabe disclose using cerium oxide. However, Maekawa and Watanabe fail to the above-mentioned surface roughness control step using the polishing liquid comprising colloidal silica abrasive grains in the polishing process and the protrusion suppressing step of changing the pressure.

Berkey et al, Okamoto et al and Shoki et al already have been distinguished. Thus, these claims are patentable for the reasons given above and for reasons given with respect to claim 1.

Claims 18/(1-2) and 19-20 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Berkey et al. (U.S. Patent No. 6,265,115) in view of either Okamoto et al. (U.S. Patent No. 6,020,109) or Shoki et al. (U.S. Pub. No. 2002/0110743), and further in view of Jacquinot et al (U.S. Patent No. 6,126,518) and Miura (U.S. Patent No. 6,027,669) as evidenced by Grant et al (Grant & Hackh's Chemical Dictionary, Fifth Ed., 1987), and further in view of Oki (U.S. Patent No. 5,581,345). This rejection is traversed for at least the following reasons.

The Claimed Invention

Claim 18 depends from claim 4 and recites the use of defect inspection using laser interference confocal optics.

Claims 19 and 20 are independent and are directed to the production of a glass substrate for a glass blank, which necessarily focuses the invention on specific quality requirements, as already discussed. As with claim 4, these claims have been amended to specify the presence of protrusions that cause phase defects and the use of an alkali metal content in colloidal silica abrasive grains at a level of 0.1 ppm or less. This permits the suppression of protrusions and the achievement of the desired phase performance.

The Prior Art

Oki et al is merely cited for its teachings of the use of confocal laser scanning mode interference contrast microscope apparatus of system for a method of measuring minute step height. This appears to be relevant only to claim 18, and not claims 19 or 20. Nonetheless, Oki et al does not remedy the deficiencies of the other cited art, as already discussed.

Claim 18(4) is rejected under 35 U.S.C. § 103(a) as being unpatentable over Yoshikawa et al. (U.S. Pub. No. 2003/0228461) in view of Watanabe et al. (U.S. Patent No. 6,277,465), and Maekawa et al. (U.S. Patent No. 5,868,953), and further in view of Berkey et al. (U.S. Patent No. 6,265,115) and either Okamoto et al. (U.S. Patent No. 6,020,109) or Shoki et al. (U.S. Pub. No. 2002/0110743) and further in view of Oki (U.S. Patent No. 5,581,345). This rejection is traversed for at least the following reasons.

The Claimed Invention

Claim 18 depends from claim 4 and recites the use of defect inspection using laser interference confocal optics.

The Prior Art

Oki et al is merely cited for its teachings of the use of confocal laser scanning mode interference contrast microscope apparatus of system for a method of measuring minute step height. As already noted, Oki et al does not remedy the deficiencies of the other cited art, as already discussed.

Conclusion

As discussed above, the present invention is significantly different from the cited references in application, goal and result, and thus is clearly patentable over the cited references.

Furthermore, in the Examiner's "Response to Arguments" at page 16 in the Office Action, the Examiner states that "the features upon which Applicants reply (e.g., removal of a phase defect due to fine protrusions present on a principal surface of a glass substrate (for a mask blank), etc.) are not recited in the rejected claims(s)". However, this feature is now recited in the claims. From this viewpoint, the present invention is clearly patentable over the cited references.

In view of the above, reconsideration and allowance of this application are now believed to be in order, and such actions are hereby solicited. If any points remain in issue which the Examiner feels may be best resolved through a personal or telephone interview, the Examiner is kindly requested to contact the undersigned at the telephone number listed below.

The USPTO is directed and authorized to charge all required fees, except for the Issue Fee and the Publication Fee, to Deposit Account No. 19-4880. Please also credit any overpayments to said Deposit Account.

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